CHAPTER 12 (Odd)

1. $e = N\frac{d\phi}{dt} = (50\text{ t})(0.085\text{ Wb/s}) = \mathbf{4.25\text{ V}}$

3. $N = \dfrac{e_{\text{ind}}}{\frac{d\phi}{dt}} = \dfrac{42\text{ mV}}{3 \times 10^{-3}\text{ Wb/s}} = \mathbf{14\text{ turns}}$

5. $d = 0.25\ \cancel{\text{in.}}\left[\dfrac{1\text{ m}}{39.37\ \cancel{\text{in.}}}\right] = \mathbf{6.35\text{ mm}}$

$$A = \frac{\pi d^2}{4} = \frac{(3.14)(6.35 \times 10^{-3}\text{ m})^2}{4} = 31.65 \times 10^{-6}\text{ m}^2$$

$$\ell = 4\ \cancel{\text{in.}}\left[\frac{1\text{ m}}{39.37\ \cancel{\text{in.}}}\right] = 0.1016\text{ m}$$

$$L = \frac{N^2\mu_r\mu_o A}{\ell} = \frac{(200\text{ t})^2(1)(4\pi \times 10^{-7})(31.65 \times 10^{-6}\text{ m}^2)}{0.1016\text{ m}} = \mathbf{15.65\ \mu H}$$

7. a. $e_L = L\frac{di}{dt} = (5\text{ H})(0.5\text{ A/s}) = \mathbf{2.5\text{ V}}$

b. $e_L = (5\text{ H})(60 \times 10^{-3}\text{ A/s}) = \mathbf{0.3\text{ V}}$

c. $e_L = (5\text{ H})(0.04 \times 10^3\text{ A/s}) = \mathbf{200\text{ V}}$

9. $e_L = L\frac{\Delta i}{\Delta t}$: $0 - 3$ ms, $e_L = \mathbf{0\text{ V}}$

$3 - 8$ ms, $e_L = (200\text{ mH})\left[\dfrac{40 \times 10^{-3}\text{ A}}{5 \times 10^{-3}\text{ s}}\right] = \mathbf{1.6\text{ V}}$

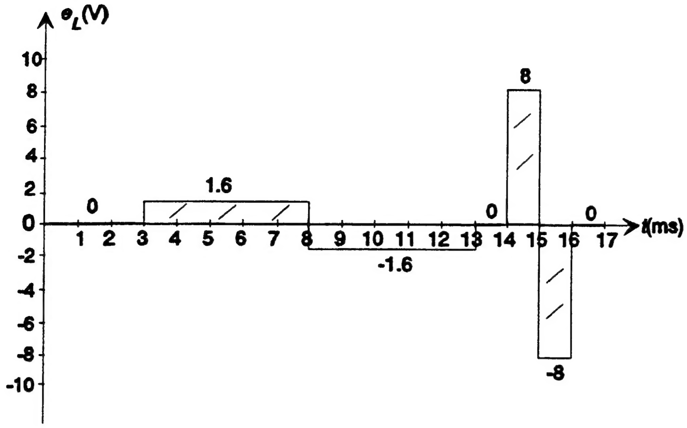
$8 - 13$ ms, $e_L = -(200\text{ mH})\left[\dfrac{40 \times 10^{-3}\text{ A}}{5 \times 10^{-3}\text{ s}}\right] = \mathbf{-1.6\text{ V}}$

$13 - 14$ ms, $e_L = \mathbf{0\text{ V}}$

$14 - 15$ ms, $e_L = (200\text{ mH})\left[\dfrac{40 \times 10^{-3}\text{ A}}{5 \times 10^{-3}\text{ s}}\right] = \mathbf{8\text{ V}}$

$15 - 16$ ms, $e_L = \mathbf{-8\text{ V}}$

$16 - 17$ ms, $e_L = \mathbf{0\text{ V}}$



11. $L = 10$ mH, 4 mA at $t = 0$ s

$$v_L = L\frac{\Delta i}{\Delta t} \Rightarrow \Delta i = \frac{\Delta t}{L}v_L$$

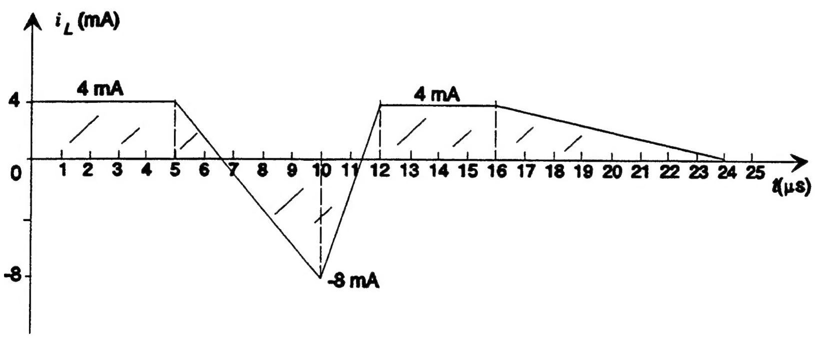
0 − 5 μs: $v_L = 0$ V, $\Delta i_L = 0$ mA and $i_L =$ **4 mA**

5 − 10 μs: $\Delta i_L = \dfrac{5\ \mu\text{s}}{10\ \text{mH}}(-24\ \text{V}) = \mathbf{-12\ mA}$

10 − 12 μs: $\Delta i_L = \dfrac{2\ \mu\text{s}}{10\ \text{mH}}(+60\ \text{V}) = \mathbf{+12\ mA}$

12 − 16 μs: $v_L = 0$ V, $\Delta i_L = 0$ mA and $i_L =$ **4 mA**

16 − 24 μs: $\Delta i_L = \dfrac{8\ \mu\text{s}}{10\ \text{mH}}(-5\ \text{V}) = \mathbf{-4\ mA}$



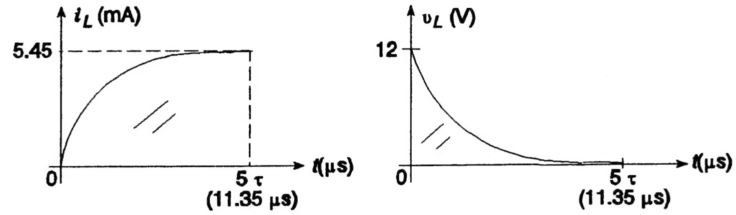
13. a. $\tau = \dfrac{L}{R} = \dfrac{5\ \text{mH}}{2.2\ \text{k}\Omega} = \mathbf{2.27\ \mu s}$

b. $i_L = \dfrac{E}{R}(1 - e^{-t/\tau}) = \dfrac{12\ \text{V}}{2.2\ \text{k}\Omega}(1 - e^{-t/\tau}) = \mathbf{5.45 \times 10^{-3}(1 - e^{-t/2.27\ \mu s})}$

c. $v_L = Ee^{-t/\tau} = \mathbf{12e^{-t/2.27\ \mu s}}$
$v_R = i_R R = i_L R = E(1 - e^{-t/\tau}) = \mathbf{12(1 - e^{-t/2.27\ \mu s})}$

d. i_L: $1\tau =$ **3.45 mA**, $3\tau =$ **5.179 mA**, $5\tau =$ **5.413 mA**
v_L: $1\tau =$ **4.415 V**, $3\tau =$ **0.598 V**, $5\tau =$ **0.081 V**

e.



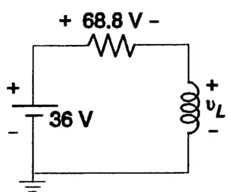
15. a. $\tau = \dfrac{L}{R} = \dfrac{120 \text{ mH}}{4.7 \text{ k}\Omega + 3.9 \text{ k}\Omega} = \dfrac{120 \text{ mH}}{8.6 \text{ k}\Omega} = 13.95\ \mu\text{s}$

$i_L = I_f + (I_i - I_f)e^{-t/\tau}$

$I_f = \dfrac{36 \text{ V}}{8.6 \text{ k}\Omega} = 4.186 \text{ mA}$

$i_L = 4.186 \text{ mA} + (8 \text{ mA} - 4.186 \text{ mA})e^{-t/13.95\ \mu\text{s}}$

$i_L = \mathbf{4.186\ mA - 3.814\ mA}e^{-t/13.95\ \mu\text{s}}$



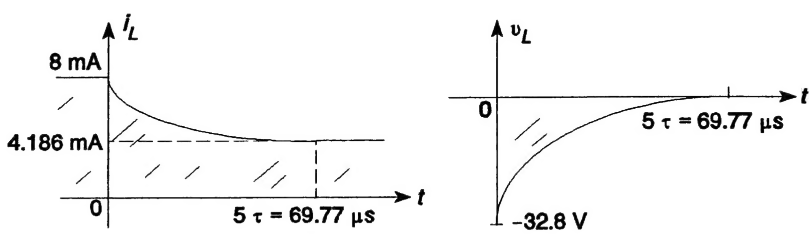
$v_{R_T}(0+) = 8 \text{ mA}(8.6 \text{ k}\Omega) = 68.8 \text{ V}$

KVL: $+36 \text{ V} - 68.8 \text{ V} - v_L = 0$,

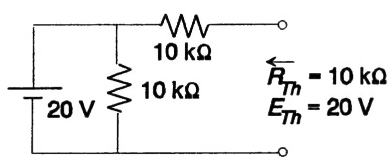
$v_L(0+) = 36 \text{ V} - 68.8 \text{ V} = -32.8 \text{ V}$

$v_L = \mathbf{-32.8\ V}e^{-t/13.95\ \mu\text{s}}$

b.



17. a.



$\tau = \dfrac{L}{R} = \dfrac{10 \text{ mH}}{10 \text{ k}\Omega} = 1\ \mu\text{s}$

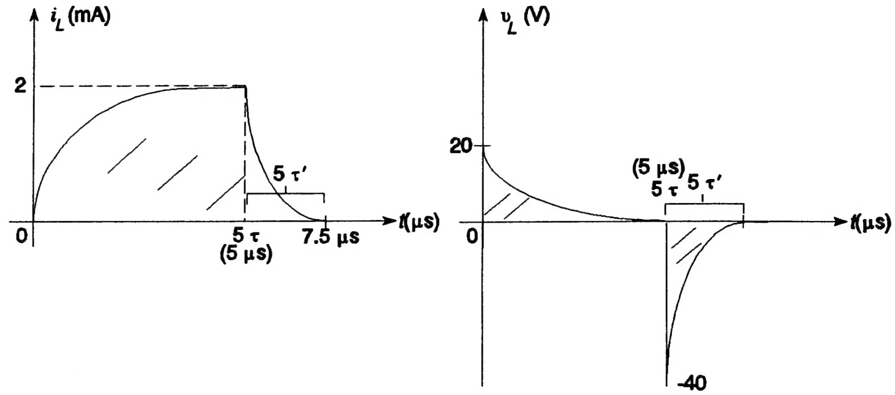
$v_L = \mathbf{20}e^{-t/1\ \mu\text{s}}$, $i_L = \dfrac{E}{R}(1 - e^{-t/\tau}) = \mathbf{2 \times 10^{-3}(1 - e^{-t/1\ \mu\text{s}})}$

b. $5\tau \Rightarrow$ steady state

$\tau' = \dfrac{L}{R} = \dfrac{10 \text{ mH}}{20 \text{ k}\Omega} = 0.5\ \mu\text{s}$

$i_L = I_m e^{-t/\tau'} = \mathbf{2 \times 10^{-3}}e^{-t/0.5\ \mu\text{s}}$

$v_L = -(2 \text{ mA})(20 \text{ k}\Omega)e^{-t/\tau} = \mathbf{-40}e^{-t/0.5\ \mu\text{s}}$



19. a. $\tau = \dfrac{L}{R} = \dfrac{1 \text{ mH}}{2 \text{ k}\Omega} = 0.5\ \mu\text{s}$

$i_L = \dfrac{E}{R}(1 - e^{-t/\tau}) = \dfrac{12 \text{ V}}{2 \text{ k}\Omega}(1 - e^{-t/\tau}) = \mathbf{6 \times 10^{-3}(1 - e^{-t/0.5\ \mu s})}$

$v_L = Ee^{-t/\tau} = \mathbf{12e^{-t/0.5\ \mu s}}$

b. $i_L = 6 \times 10^{-3}(1 - e^{-t/0.5\ \mu s}) = 6 \times 10^{-3}(1 - e^{-1\ \mu s/0.5\ \mu s})$
$= 6 \times 10^{-3}(1 - e^{-2}) = 5.188$ mA

$i_L = I'_m e^{-t/\tau'}$ $\qquad \tau' = \dfrac{L}{R} = \dfrac{1 \text{ mH}}{12 \text{ k}\Omega} = 0.0833\ \mu\text{s} = 83.3$ ns

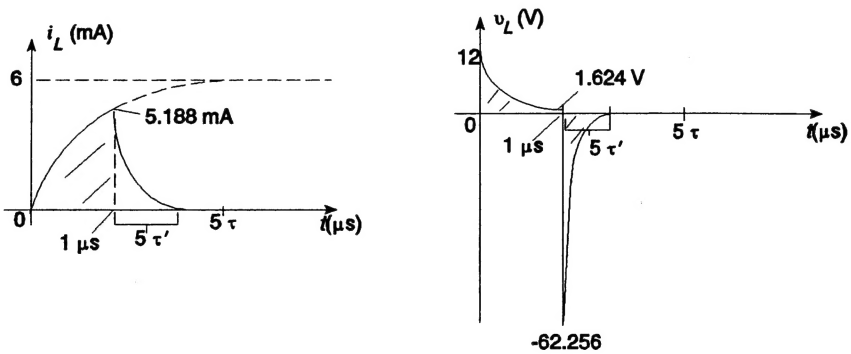
$i_L = \mathbf{5.188 \times 10^{-3} e^{-t/83.3\ ns}}$

$t = 1\ \mu\text{s}$: $v_L = 12e^{-t/0.5\ \mu s} = 12e^{-2} = 12(0.1353) = 1.624$ V

$V'_L = (5.188 \text{ mA})(12 \text{ k}\Omega) = 62.256$ V

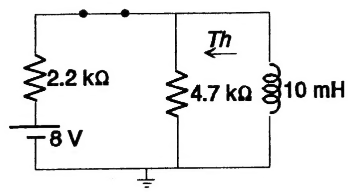
$v_L = \mathbf{-62.256e^{-t/83.3\ ns}}$

c.



21.

$$
\begin{aligned}
2 \text{ mA} &= 1.78 \text{ mA} + 2.22 \text{ mA}e^{-t/11.11\ \mu s} \\
0.22 \text{ mA} &= 2.22 \text{ mA}e^{-t/11.11\ \mu s} \\
99.1 \times 10^{-3} &= e^{-t/11.11\ \mu s} \\
\log_e 99.1 \times 10^{-3} &= \log_e(e^{-t/11.11\ \mu s}) \\
-2.312 &= -t/11.11\ \mu s \\
t &= (11.11\ \mu s)(2.312) \\
t &= \mathbf{25.68\ \mu s}
\end{aligned}
$$

23. a. 

$$R_{Th} = 2.2\text{ k}\Omega \| 4.7\text{ k}\Omega = 1.498\text{ k}\Omega$$

$$E_{Th} = \frac{4.7\text{ k}\Omega(8\text{ V})}{4.7\text{ k}\Omega + 2.2\text{ k}\Omega} = 5.45\text{ V}$$

$$\tau = \frac{L}{R} = \frac{10\text{ mH}}{1.498\text{ k}\Omega} = 6.676\ \mu\text{s}$$

$$i_L = \frac{E}{R}(1 - e^{-t/\tau}) = \frac{5.45\text{ V}}{1.498\text{ k}\Omega}(1 - e^{-t/\tau}) = \mathbf{3.638 \times 10^{-3}(1 - e^{-t/6.676\ \mu s})}$$

$$v_L = Ee^{-t/\tau} = \mathbf{5.45e^{-t/6.676\ \mu s}}$$

b. $t = 10\ \mu$s:

$$i_L = 3.638 \times 10^{-3}(1 - e^{-10\ \mu s/6.676\ \mu s}) = 3.638 \times 10^{-3}(1 - \underbrace{e^{-1.4}}_{0.2236})$$

$$= \mathbf{2.825\ mA}$$

$$v_L = 5.45(0.2236) = \mathbf{1.2186\ V}$$

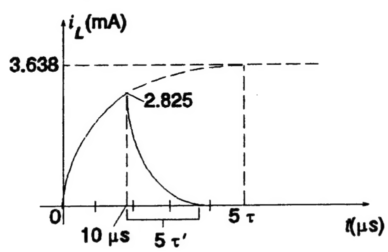
c. $$\tau' = \frac{L}{R} = \frac{10\text{ mH}}{4.7\text{ k}\Omega} = 2.128\ \mu\text{s}$$

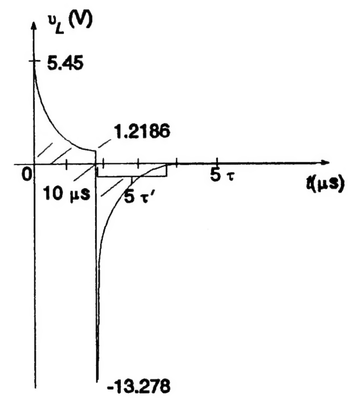
$$i_L = \mathbf{2.825 \times 10^{-3}e^{-t/2.128\ \mu s}}$$

At $t = 10\ \mu$s:

$$V_L = (2.825\text{ mA})(4.7\text{ k}\Omega) = 13.278\text{ V}$$

$$v_L = \mathbf{-13.278e^{-t/2.128\ \mu s}}$$





25. a. $v_L = Ee^{-t/\tau}$ $\qquad \tau = \dfrac{L}{R_1 + R_3} = \dfrac{0.6\text{ H}}{100\ \Omega + 20\ \Omega} = \dfrac{0.6\text{ H}}{120\ \Omega} = 5\text{ ms}$

$$v_L = 36\ e^{-t/5\text{ ms}}$$

$$v_L = 36\ e^{-25\text{ ms}/5\text{ ms}} = 36\ e^{-5} = 36(0.00674) = \mathbf{0.243\ V}$$

b. $$v_L = 36\ e^{-1\text{ ms}/5\text{ ms}} = 36\ e^{-0.2} = 36(0.819) = \mathbf{29.47\ V}$$

c. $$v_{R_1} = i_{R_1}R_1 = i_L R_1 = \left[\frac{E}{R_1 + R_3}(1 - e^{-t/\tau})\right]R_1$$

$$= \left[\frac{36\text{ V}}{120\ \Omega}(1 - e^{-t/5\text{ ms}})\right]100\ \Omega$$

$$= (300\text{ mA}(1 - e^{-t/5\text{ ms}}))100\ \Omega$$

$$= 30\text{ V}(1 - e^{-5\text{ ms}/5\text{ ms}}) = 30\text{ V}(1 - e^{-1})$$

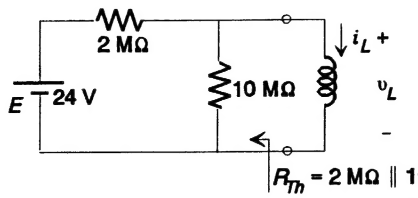
$$= 30\text{ V}(1 - 0.368) = \mathbf{18.96\ V}$$

d.
$$
\begin{aligned}
i_L &= 300\text{ mA}(1 - e^{-t/5\text{ ms}})\\
100\text{ mA} &= 300\text{ mA}(1 - e^{-t/5\text{ ms}})\\
0.333 &= 1 - e^{-t/5\text{ ms}}\\
0.667 &= e^{-t/5\text{ ms}}\\
\log_e 0.667 &= -t/5\text{ ms}\\
0.405 &= t/5\text{ ms}\\
t &= 0.405(5\text{ ms}) = \mathbf{2.025\text{ ms}}
\end{aligned}
$$

27. a. $L \Rightarrow$ open circuit equivalent

$$V_L = \frac{10\text{ M}\Omega(24\text{ V})}{10\text{ M}\Omega + 2\text{ M}\Omega} = \mathbf{20\text{ V}}$$

b.



$R_{Th} = 2\text{ M}\Omega \parallel 10\text{ M}\Omega = 1.667\text{ M}\Omega$

$$E_{Th} = \frac{10\text{ M}\Omega(24\text{ V})}{10\text{ M}\Omega + 2\text{ M}\Omega} = 20\text{ V}$$

$$I_{L_{\text{final}}} = \frac{E_{Th}}{R_{Th}} = \frac{20\text{ V}}{1.667\text{ M}\Omega} = \mathbf{12\ \mu A}$$

c.
$$
\begin{aligned}
i_L &= 12\ \mu\text{A}(1 - e^{-t/3\ \mu\text{s}})\\
10\ \mu\text{A} &= 12\ \mu\text{A}(1 - e^{-t/3\ \mu\text{s}})\\
0.8333 &= 1 - e^{-t/3\ \mu\text{s}}\\
0.1667 &= e^{-t/3\ \mu\text{s}}\\
\log_e(0.1667) &= -t/3\ \mu\text{s}\\
1.792 &= t/3\ \mu\text{s}\\
t &= 1.792(3\ \mu\text{s}) = \mathbf{5.376\ \mu s}
\end{aligned}
$$

$$\tau = \frac{L}{R} = \frac{5\text{ H}}{1.667\text{ M}\Omega} = 3\ \mu\text{s}$$

d.
$$
\begin{aligned}
v_L &= 20e^{-t/3\ \mu\text{s}} = 20e^{-12\ \mu\text{s}/3\ \mu\text{s}} = 20e^{-4}\\
&= 20(0.0183) = \mathbf{0.366\text{ V}}
\end{aligned}
$$

29. a. $I_i = -\dfrac{24\text{ V}}{2.2\text{ k}\Omega} = -10.91\text{ mA}$

Switch open: $I_f = -\dfrac{24\text{ V}}{2.2\text{ k}\Omega + 4.7\text{ k}\Omega} = -\dfrac{24\text{ V}}{6.9\text{ k}\Omega} = -3.478\text{ mA}$

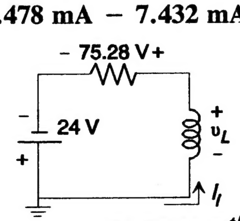
$i_L = I_f + (I_i - I_f)e^{-t/\tau}$

$$\tau = \frac{L}{R} = \frac{1.2\text{ H}}{6.9\text{ k}\Omega} = 173.9\ \mu\text{s}$$

$i_L = -3.478\text{ mA} + (-10.91\text{ mA} - (-3.478\text{ mA}))e^{-t/173.9\ \mu\text{s}}$

$\mathbf{i_L = -3.478\text{ mA} - 7.432\text{ mA}e^{-t/173.9\ \mu s}}$

$t = 0+$:



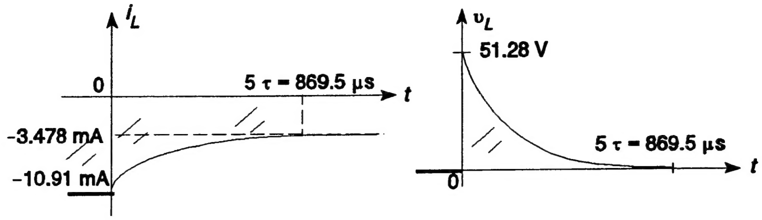
$v_L = \mathbf{51.28\text{ V}e^{-t/173.9\ \mu s}}$

$v_R(0+) = (10.91\text{ mA})(6.9\text{ k}\Omega) = 75.28\text{ V}$

KVL: $-24\text{ V} + 75.28\text{ V} - v_L = 0$

$v_L = 51.28\text{ V}$

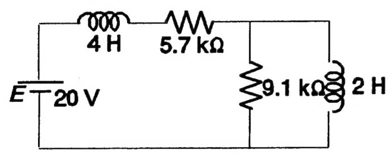
b.



31. a. $L_T = 4\text{ H} + 2\text{ H} + 3\text{ H}\|6\text{ H} = \mathbf{8\text{ H}}$

b. $L_T = 12\text{ H}\|(3.6\text{ H} + 4\text{ H}\|6\text{ H}) = 12\text{ H}\|6\text{ H} = \mathbf{4\text{ H}}$

33. $L'_T = 6\text{ H}\|(1\text{ H} + 2\text{ H}) = 6\text{ H}\|3\text{ H} = 2\text{ H}$



35. $I_1 = \dfrac{16\text{ V}}{4\text{ k}\Omega + 0} = \mathbf{4\text{ mA}},\ V_1 = \mathbf{16\text{ V}},\ V_2 = \mathbf{0\text{ V}}$

37. $V_1 = \dfrac{(3\ \Omega + 3\Omega\|6\ \Omega)(50\text{ V})}{(3\ \Omega + 3\ \Omega\|6\Omega) + 20\ \Omega} = \dfrac{(3\ \Omega + 2\ \Omega)(50\text{ V})}{(3\ \Omega + 2\ \Omega) + 20\ \Omega} = \mathbf{10\text{ V}}$

$R_T = 20\ \Omega + 3\ \Omega + 3\ \Omega \parallel 6\ \Omega = 23\ \Omega + 2\ \Omega = 25\ \Omega$

$I_s = I_1 = \dfrac{50\text{ V}}{25\ \Omega} = \mathbf{2\text{ A}}$

$I_{5\Omega} = 0\text{ A},\ \therefore\ I_2 = \dfrac{6\ \Omega(I_s)}{6\ \Omega + 3\ \Omega} = \dfrac{6\ \Omega(2\text{ A})}{6\ \Omega + 3\ \Omega} = \mathbf{1.33\text{ A}}$

39. $W_{5\mu\text{F}} = \dfrac{1}{2}CV^2 = \dfrac{1}{2}(5\ \mu\text{F})(12\text{ V})^2 = \mathbf{360\ \mu J}$

$W_{6\text{H}} = \dfrac{1}{2}LI^2 = \dfrac{1}{2}(6\text{ H})(2\text{ A})^2 = \mathbf{12\text{ J}}$

CHAPTER 12 (Even)

2. $e = N\dfrac{d\phi}{dt} \Rightarrow \dfrac{d\phi}{dt} = \dfrac{e}{N} = \dfrac{20\text{ V}}{40\text{ t}} = \mathbf{0.5\ Wb/s}$

4. $A = \dfrac{\pi d^2}{4} = \dfrac{\pi(5\text{ mm})^2}{4} = 19.625 \times 10^{-6}\text{ m}^2$

$$L = \frac{N^2\mu A}{\ell} = \frac{(200\text{ t})^2(4\pi \times 10^{-7})(19.625 \times 10^{-6}\text{ m}^2)}{0.075\text{ m}} = \mathbf{13.146\ \mu H}$$

6. a. $L = \dfrac{N^2\mu A}{\ell} = \dfrac{(300\text{ t})^2(4\pi \times 10^{-7})(1.5 \times 10^{-4}\text{ m}^2)}{0.1\text{ m}} = \mathbf{169.56\ \mu H}$

b. $L = \mu_r L_o = (2 \times 10^3)(169.56\ \mu\text{H}) = \mathbf{339.12\ mH}$

8. $e_L = L\dfrac{di}{dt} = (50\text{ mH})\left[\dfrac{0.1 \times 10^{-3}\text{ A}}{10^{-6}\text{ s}}\right] = \mathbf{5\ V}$

10. $e = L\dfrac{\Delta i}{\Delta t} = (0.2\text{ H})\dfrac{\Delta i}{\Delta t}$

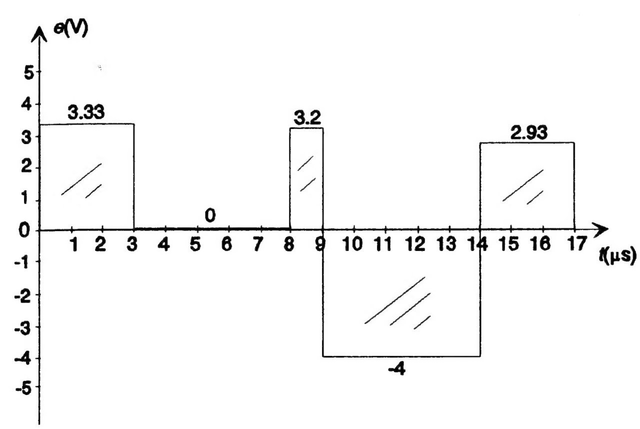
$0 - 3\ \mu\text{s}$: $e = (0.2\text{ H})\left[\dfrac{50\ \mu\text{A}}{3\ \mu\text{s}}\right] = 3.33\text{ V}$

$3 - 8\ \mu\text{s}$: $e = (0.2\text{ H})(0) = 0\text{ V}$

$8 - 9\ \mu\text{s}$: $e = (0.2\text{ H})\left[\dfrac{16\ \mu\text{A}}{1\ \mu\text{s}}\right] = 3.2\text{ V}$

$9 - 14\ \mu\text{s}$: $e = -(0.2\text{ H})\left[\dfrac{100\ \mu\text{A}}{5\ \mu\text{s}}\right] = -4\text{ V}$

$14 - 17\ \mu\text{s}$: $e = (0.2\text{ H})\left[\dfrac{44\ \mu\text{A}}{3\ \mu\text{s}}\right] = 2.93\text{ V}$



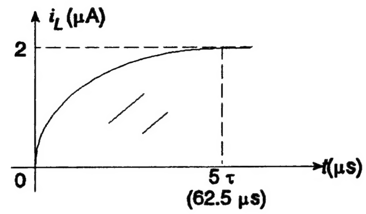
12. a. $\tau = \dfrac{L}{R} = \dfrac{250\text{ mH}}{20\text{ k}\Omega} = \mathbf{12.5\ \mu s}$

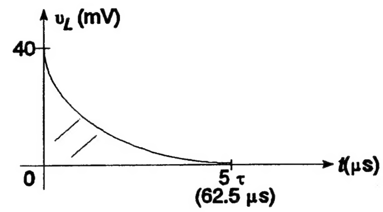
b. $i_L = \dfrac{E}{R}(1 - e^{-t/\tau}) = \dfrac{40\text{ mV}}{20\text{ k}\Omega}(1 - e^{-t/\tau})$
$= \mathbf{2 \times 10^{-6}(1 - e^{-t/12.5\ \mu s})}$

c. $v_L = Ee^{-t/\tau} = \mathbf{40 \times 10^{-3}e^{-t/12.5\ \mu s}}$
$v_R = i_R R = i_L R = E(1 - e^{-t/\tau}) = \mathbf{40 \times 10^{-3}(1 - e^{-t/12.5\ \mu s})}$

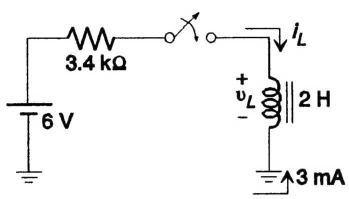
d. i_L: $1\tau = 1.264\ \mu\text{A}$, $3\tau = 1.9\ \mu\text{A}$, $5\tau = 1.987\ \mu\text{A}$
v_L: $1\tau = 14.72$ V, $3\tau = 1.99$ V, $5\tau = 0.2695$ V

e.

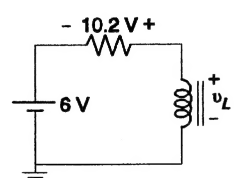




14. a. Source conversion:

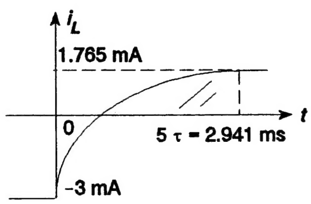


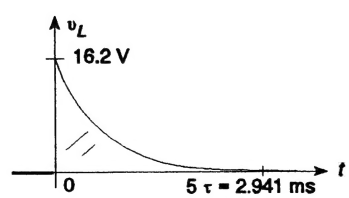
$\tau = \dfrac{L}{R} = \dfrac{2\text{ H}}{3.4\text{ k}\Omega} = 588.2\ \mu\text{s}$
$i_L = I_f + (I_i - I_f)e^{-t/\tau}$
$I_f = \dfrac{6\text{ V}}{3.4\text{ k}\Omega} = 1.765\text{ mA}$
$i_L = 1.765\text{ mA} + (-3\text{ mA} - 1.765\text{ mA})e^{-t/588.2\ \mu s}$
$i_L = \mathbf{1.765\ mA + 4.765\ mA}e^{-t/588.2\ \mu s}$



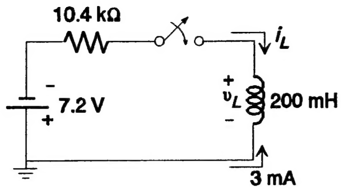
$v_R(0+) = 3\text{ mA}(3.4\text{ k}\Omega) = 10.2\text{ V}$
KVL: $+6\text{ V} + 10.2\text{ V} - v_L(0+) = 0$
$v_L(0+) = 16.2\text{ V}$
$v_L = \mathbf{16.2\ V}e^{-t/588.2\ \mu s}$

b.





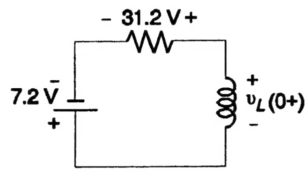
16. a.



$$I_f = -\frac{7.2\text{ V}}{10.4\text{ k}\Omega} = -0.692\text{ mA}$$

$$\tau = \frac{L}{R} = \frac{200\text{ mH}}{10.4\text{ k}\Omega} = 19.23\ \mu\text{s}$$

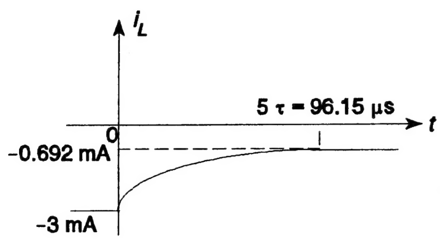
$$i_L = I_f + (I_i - I_f)e^{-t/\tau}$$
$$= -0.692\text{ mA} + (-3\text{ mA} - (-0.692\text{ mA}))e^{-t/19.23\ \mu\text{s}}$$
$$i_L = \mathbf{-0.692\ mA - 2.308\ mA}e^{-t/19.23\ \mu\text{s}}$$

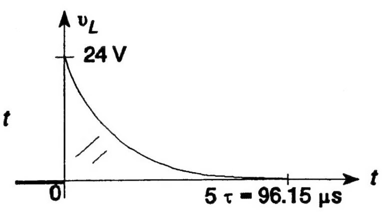


KVL: $-7.2\text{ V} + 31.2\text{ V} - v_L(0+) = 0$

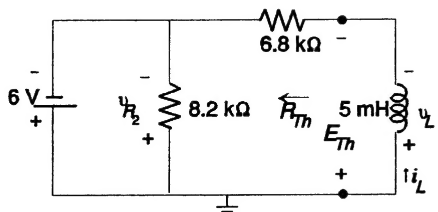
$$v_L(0+) = 24\text{ V}$$
$$v_L = \mathbf{24\ V}e^{-t/19.23\ \mu\text{s}}$$

b.

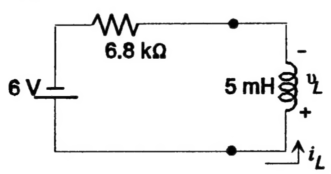




18. a.



$R_{Th} = 6.8\text{ k}\Omega$
$E_{Th} = 6\text{ V}$

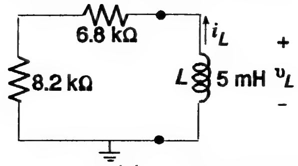


$$\tau = \frac{L}{R} = \frac{5\text{ mH}}{6.8\text{ k}\Omega} = 0.735\ \mu\text{s}$$

$$i_L = \frac{E}{R}(1 - e^{-t/\tau}) = \frac{6\text{ V}}{6.8\text{ k}\Omega}(1 - e^{-t/\tau}) = \mathbf{0.882 \times 10^{-3}(1 - e^{-t/0.735\ \mu s})}$$

$$v_L = Ee^{-t/\tau} = \mathbf{6e^{-t/0.735\ \mu s}}$$

b. Assume steady state and $I_L = 0.882$ mA



$$\tau' = \frac{L}{R} = \frac{5 \text{ mH}}{15 \text{ k}\Omega} = 0.333 \ \mu\text{s}$$

$i_L = I_m e^{-t/\tau'} = \mathbf{0.882 \times 10^{-3} e^{-t/0.333\,\mu s}}$

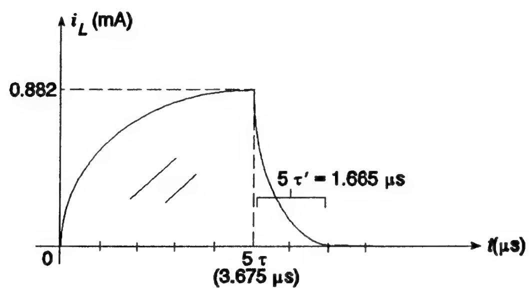
$v_L = -V_m e^{-t/\tau'}$

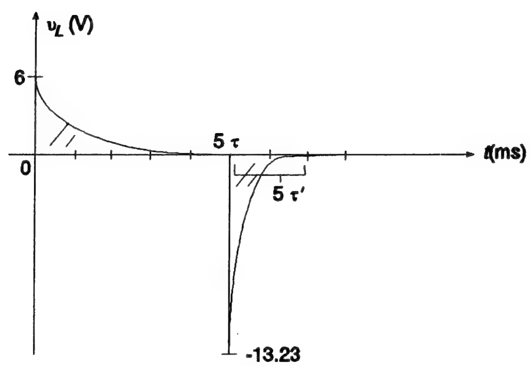
↑ compared to defined polarity of Fig. 12.64.

$V_m = I_m R = (0.882 \text{ mA})(15 \text{ k}\Omega) = 13.23$ V

$v_L = \mathbf{-13.23\ e^{-t/0.333\,\mu s}}$

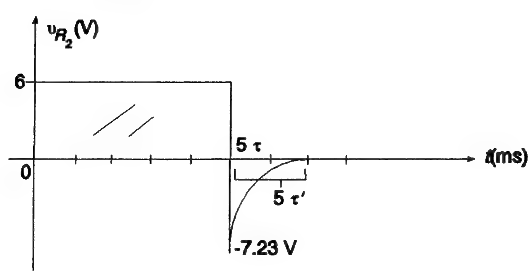
c.





d. For polarity of Fig. 12.64:

$V_{R_2 \max} = I_m R_2 = (0.882 \text{ mA})(8.2 \text{ k}\Omega) = 7.23$ V



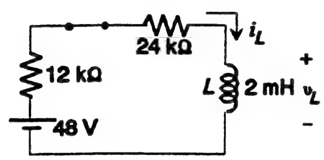
20. $i_L = 10$ mA: Eq. 12.21

$$t = \tau \log_e \left[\frac{I_m}{I_m - i_L}\right] = 2 \text{ ms} \log_e \left[\frac{25 \text{ mA}}{25 \text{ mA} - 10 \text{ mA}}\right]$$
$$= 2 \text{ ms} \log_e \left[\frac{25 \text{ mA}}{15 \text{ mA}}\right] = 2 \text{ ms} \log_e 1.667$$
$$= 2 \text{ ms} (0.511)$$
$$= \mathbf{1.02 \text{ ms}}$$

$v_L = 10$ V: Eq. 12.22

$$t = \tau \log_e \frac{E}{v_L} = 2 \text{ ms} \log_e \frac{50 \text{ V}}{10 \text{ V}}$$
$$= 2 \text{ ms} \log_e 5 = 2 \text{ ms}(1.609)$$
$$= \mathbf{3.219 \text{ ms}}$$

22. a. Source conversion: $E = IR = (4 \text{ mA})(12 \text{ k}\Omega) = 48$ V



$$\tau = \frac{L}{R} = \frac{2 \text{ mH}}{36 \text{ k}\Omega} = 55.56 \text{ ns}$$

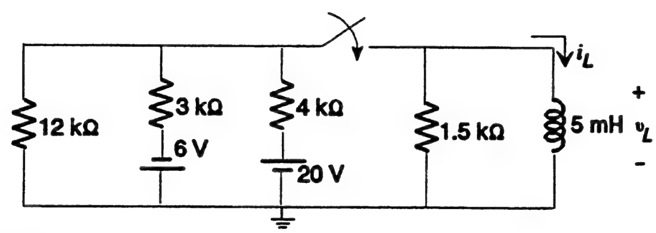
$$i_L = \frac{E}{R}(1 - e^{-t/\tau}) = \frac{48 \text{ V}}{36 \text{ k}\Omega}(1 - e^{-t/\tau}) = \mathbf{1.33 \times 10^{-3}(1 - e^{-t/55.56 \text{ ns}})}$$
$$v_L = Ee^{-t/\tau} = \mathbf{48e^{-t/55.56 \text{ ns}}}$$

b. $t = 100$ ns:

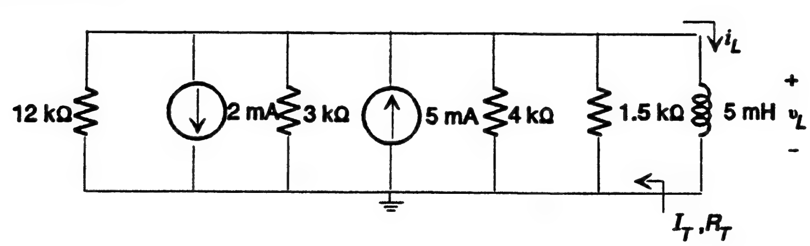
$$i_L = 1.33 \times 10^{-3}(1 - e^{-100 \text{ ns}/55.56 \text{ ns}}) = 1.33 \times 10^{-3}(1 - \underbrace{e^{-1.8}}_{0.1676}) = \mathbf{1.11 \text{ mA}}$$

$$v_L = 48e^{-1.8} = \mathbf{7.934 \text{ V}}$$

24. a. Redrawn:



Source conversions:

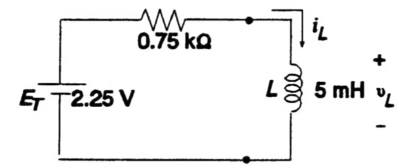


$I_T = 5 \text{ mA} - 2 \text{ mA} = 3 \text{ mA}\uparrow$

$$\frac{1}{R_T} = \frac{1}{12 \text{ k}\Omega} + \frac{1}{3 \text{ k}\Omega} + \frac{1}{4 \text{ k}\Omega} + \frac{1}{1.5 \text{ k}\Omega} = 0.75 \text{ k}\Omega$$

Source conversion:

$$E_T = I_T R_T = (3\text{ mA})(0.75\text{ k}\Omega) = 2.25\text{ V}$$



$$\tau = \frac{L}{R} = \frac{5\text{ mH}}{0.75\text{ k}\Omega} = 6.67\ \mu\text{s}$$

$$i_L = \frac{2.25\text{ V}}{0.75\text{ k}\Omega}(1 - e^{-t/\tau}) = 3 \times 10^{-3}(1 - e^{-t/6.67\ \mu\text{s}})$$

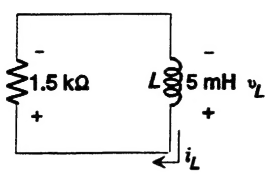
$$v_L = \mathbf{2.25\ e^{-t/6.67\ \mu s}}$$

b. 2τ: $0.865\ I_m$, $0.135\ V_m$

i_L: $0.865\ (3\text{ mA}) = \mathbf{2.595\ mA}$

v_L: $0.135(2.25\text{ V}) = \mathbf{0.304\ V}$

c.



$$\tau' = \frac{L}{R} = \frac{5\text{ mH}}{1.5\text{ k}\Omega} = 3.33\ \mu\text{s}$$

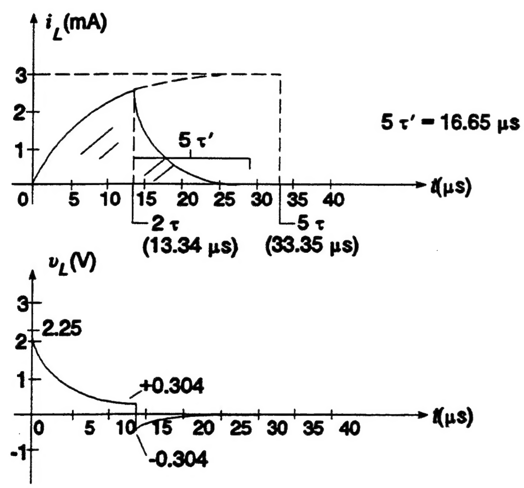
$$i_L = \mathbf{2.595 \times 10^{-3} e^{-t/3.33\ \mu s}}$$

$$i_L(0+) = 2.595\text{ mA}$$

$$v_R(0+) = (2.595\text{ mA})(1.5\text{ k}\Omega) = 3.893\text{ V}$$

$$v_L = \mathbf{-3.893\ V e^{-t/3.33\ \mu s}}$$

d.



26. a. $i_L = \dfrac{E}{R_1 + R_2}e^{-t/\tau}$ $\qquad \tau = \dfrac{L}{R_T} = \dfrac{L}{R_1 + R_2 + R_3} = \dfrac{0.6 \text{ H}}{590 \ \Omega} = 1.017\text{ms}$

$$= \frac{36 \text{ V}}{100 \ \Omega + 20 \ \Omega}e^{-t/1.017 \text{ ms}}$$

$$i_L = 300 \text{ mA } e^{-t/1.017 \text{ ms}}$$
$$1 \text{ mA} = 300 \text{ mA } e^{-t/1.017 \text{ ms}}$$
$$3.333 \times 10^{-3} = e^{-t/1.017 \text{ ms}}$$
$$\log_e (3.333 \times 10^{-3}) = -t/1.017 \text{ ms}$$
$$-5.704 = -t/1.017 \text{ ms}$$
$$t = 5.704(1.017 \text{ ms}) = \mathbf{5.801 \text{ ms}}$$

b. $v_{L_{max}} = I_{L_{max}}(R_1 + R_2 + R_3) = (300 \text{ mA})(590 \ \Omega) = 177 \text{ V}$

$v_L = -177e^{-t/\tau} = -177e^{-t/1.017 \text{ ms}}$

$v_L = -177e^{-1 \text{ ms}/1.017 \text{ ms}} = -177e^{-0.983}$

$= -177(0.374) = \mathbf{-66.198 \text{ V}}$

c. $v_{R_3} = i_L R_3 = (300 \text{ mA } e^{-t/1.017 \text{ ms}})(20 \ \Omega)$

$= 6e^{-t/1.017 \text{ ms}} = 6e^{-5}$

$= 6(6.738 \times 10^{-3})$

$= \mathbf{40.428 \text{ mV}}$

28. a. $I_i = \dfrac{16 \text{ V}}{4.7 \text{ k}\Omega + 3.3 \text{ k}\Omega} = 2 \text{ mA}$

$t = 0\text{s}$: Thevenin:

$R_{Th} = 3.3 \text{ k}\Omega + 1 \text{ k}\Omega \| 4.7 \text{ k}\Omega = 3.3 \text{ k}\Omega + 0.825 \text{ k}\Omega = 4.125 \text{ k}\Omega$

$E_{Th} = \dfrac{1 \text{ k}\Omega (16 \text{ V})}{1 \text{ k}\Omega + 4.7 \text{ k}\Omega} = 2.807 \text{ V}$

$i_L = I_f + (I_i - I_f)e^{-t/\tau}$

$I_f = \dfrac{2.807 \text{ V}}{4.125 \text{ k}\Omega} = 0.680 \text{ mA}, \ \tau = \dfrac{L}{R} = \dfrac{2 \text{ H}}{4.125 \text{ k}\Omega} = 484.9 \ \mu\text{s}$

$i_L = 0.680 \text{ mA} + (2 \text{ mA} - 0.680 \text{ mA})e^{-t/484.9 \ \mu\text{s}}$

$i_L = \mathbf{0.680 \text{ mA} + 1.320 \text{ mA}e^{-t/484.9 \ \mu s}}$

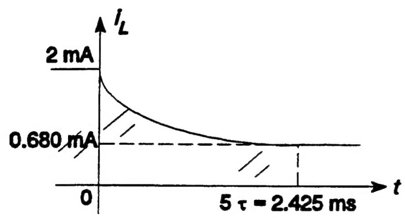
$v_R(0+) = 2 \text{ mA}(4.125 \text{ k}\Omega) = 8.25 \text{ V}$

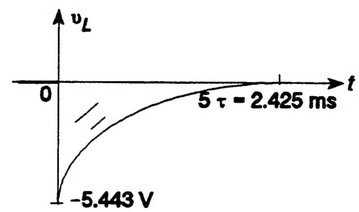
KVL(0+): $2.807 \text{ V} - 8.25 \text{ V} - v_L = 0$

$v_L = -5.443 \text{ V}$

$v_L = \mathbf{-5.44 \text{ V}e^{-t/484.9 \ \mu s}}$

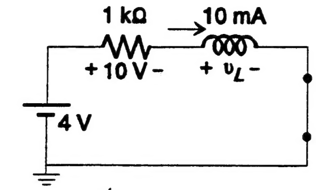
b.





30. Source conversion: $I_i = \dfrac{18\ \text{V} + 4\ \text{V}}{1\ \text{k}\Omega + 1.2\ \text{k}\Omega} = \dfrac{22\ \text{V}}{2.2\ \text{k}\Omega} = 10\ \text{mA}$

$t = 0+$:



$$I_f = \frac{4\ \text{V}}{1\ \text{k}\Omega} = 4\ \text{mA}$$

$$\tau = \frac{L}{R} = \frac{220\ \text{mH}}{1\ \text{k}\Omega} = 220\ \mu\text{s}$$

$i_L = I_f + (I_i + I_f)e^{-t/\tau}$

$\quad = 4\ \text{mA} + (10\ \text{mA} - 4\ \text{mA})e^{-t/220\ \mu\text{s}}$

$i_L = \mathbf{4\ mA + 6\ mA}e^{-t/220\ \mu\text{s}}$

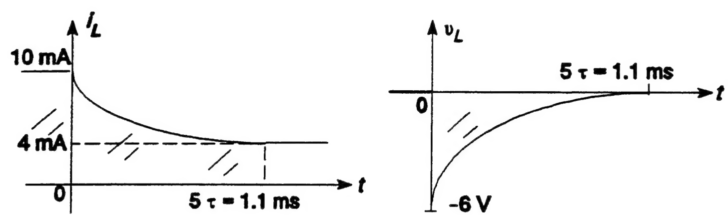
$v_R(0+) = (10\ \text{mA})(1\ \text{k}\Omega) = 10\ \text{V}$

KVL: $+4\ \text{V} - 10\ \text{V} - v_L = 0$

$v_L(0+) = -6\ \text{V}$

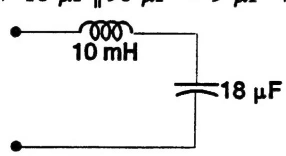
$v_L = \mathbf{-6\ V}e^{-t/220\ \mu\text{s}}$

b.



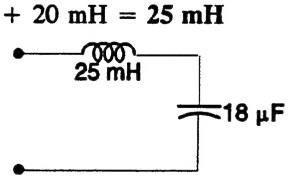
32. a. $L_T = 14\ \text{mH} \| 35\ \text{mH} = \mathbf{10\ mH}$

$C_T = 9\ \mu\text{F} + 10\ \mu\text{F} \| 90\ \mu\text{F} = 9\ \mu\text{F} + 9\ \mu\text{F} = \mathbf{18\ \mu F}$

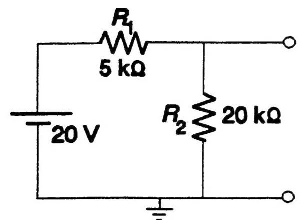


b. $C_T = 12\ \mu\text{F} + 7\ \mu\text{F} \| 42\ \mu\text{F} = 12\ \mu\text{F} + 6\ \mu\text{F} = \mathbf{18\ \mu F}$

$L_T = 5\ \text{mH} + 20\ \text{mH} = \mathbf{25\ mH}$



34. a.



$\overleftarrow{R_{Th}} = 5\text{ k}\Omega \parallel 20\text{ k}\Omega = 4\text{ k}\Omega$

$E_{Th} = \dfrac{20\text{ k}\Omega(20\text{ V})}{20\text{ k}\Omega + 5\text{ k}\Omega} = 16\text{ V}$

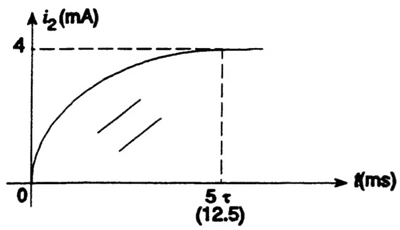
$$L_T = 5\text{ H} + 6\text{ H}\|30\text{ H} = 5\text{ H} + 5\text{ H} = \mathbf{10\text{ H}}$$

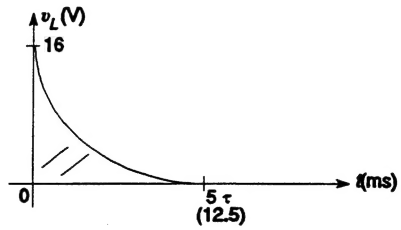
$$\tau = \frac{L_T}{R} = \frac{10\text{ H}}{4\text{ k}\Omega} = 2.5\text{ ms}$$

$$v_L = \mathbf{16e^{-t/2.5\text{ ms}}}$$

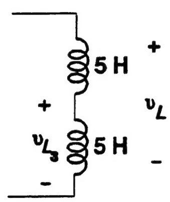
$$i_L = \frac{16\text{ V}}{4\text{ k}\Omega}(1 - e^{-t/\tau}) = \mathbf{4 \times 10^{-3}(1 - e^{-t/2.5\text{ ms}})}$$

b.





c.



$$v_{L_3} = \frac{v_L}{2} = \mathbf{8e^{-t/2.5\text{ ms}}}$$

36. $I_1 = \dfrac{20\text{ V}}{4\ \Omega + 6\ \Omega} = \mathbf{2\text{ A}},\ V_1 = 20\text{ V} - I_1\, 4\ \Omega$

$$\begin{aligned} &= 20\text{ V} - (2\text{ A})(4\ \Omega) \\ &= 20\text{ V} - 8\text{ V} \\ &= \mathbf{12\text{ V}} \end{aligned}$$

38. $W_{2\text{H}} = \dfrac{1}{2}LI^2 = \dfrac{1}{2}(2\text{ H})(4\text{ mA})^2 = \mathbf{16\ \mu J}$

$W_{3\text{H}} = \dfrac{1}{2}(3\text{ H})(4\text{ mA})^2 = \mathbf{24\ \mu J}$

40. $W_{0.5\text{H}} = \dfrac{1}{2}(0.5\text{ H})(2\text{ A})^2 = \mathbf{1\text{ J}}$

$W_{4\text{H}} = \dfrac{1}{2}(4\text{ H})(4/3\text{ A})^2 = \mathbf{3.56\text{ J}}$